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1.	Your reference	J1416 / P2639
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3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	THE SECRETARY OF STATE FOR DEFENCE DEFENCE EVALUATION AND RESEARCH AGENCY FARNBOROUGH HAMPSHIRE GU14 0LX
	Patents ADP number *(if you know it)*	734999600l
	If the applicant is a corporate body, give the country/state of its incorporation	UNITED KINGDOM
4.	Title of the invention	IMPROVEMENTS IN AND RELATING TO MICROMECHANICAL DEVICES
5.	Name of your agent *(if you have one)*	BARKER BRETTELL
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	138 HAGLEY ROAD EDGBASTON BIRMINGHAM B16 9PW
	Patents ADP number *(if you know it)*	232001

		Country	Priority application number *(if you know it)*	Date of Filing *(day/month/year)*
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DUPLICATE

IMPROVEMENTS IN AND RELATING TO MICROMECHANICAL DEVICES

This invention relates to micromechanical devices, in particular transducers, and especially to ultrasonic transducers. The term "transducer" is intended to cover any device which transmits energy from one system to another in the same or a different form. For example, acoustic or ultrasonic transducers or accelerometers which convert acoustic energy, ultrasonic energy or acceleration force into movement of a deflectable membrane or plate are considered to fall within the definition, and also actuators which convert electrical energy into movement. It is considered to cover any device (including sensors and actuators) fabricated using what can be described as micromaching techniques.

Two examples of micromechanical devices are accelerometers and ultrasonic transducers. It is known to have an ultrasonic transducer that comprises a membrane, with a formed electrode, over a resonant cavity and fixed substrate to which a second electrode is formed. The membrane is typically formed from a planar sheet of semiconductor material (such as silicon dioxide, silicon nitride, and poly silicon) applied to the substrate.

The membrane deflects upon contact with an incident ultrasonic (pressure) wave. Movement of the membrane varies the capacitance between the electrodes which can be used to detect incident acoustic waves.

Ultrasonic transducers with a semiconductor membrane operate well, but with high quality factor (high Q), due to the relatively high intrinsic rigidity associated with the material used for the membrane.

There are circumstances where a high Q is not desirable. For example, during medical imaging, guidance and positioning, and structural inspection (e.g. of articles) a high bandwidth, low Q, acoustic detector is required. Ultrasonic high Q, low bandwidth, detectors are not suitable for this purpose.

It has been reported in the paper by D.W. Schnidel and D.A. Hutchins, IEEE Trans. on Ultrasonics Ferroelectrics and Frequency Control vol. 42, number 1, January 1995, that if transducers are fabricated by adhering a PCB polymer sheet as a membrane onto a substrate a low Q, high bandwidth, transducer may be achievable. This process for manufacturing such transducers has a low yield and does not give reproducible results. It is difficult to produce many transducers which have similar or identical properties. Bonding the sheet of polymer to the silicon substrate is not easy. Obtaining a uniform bond, with no areas of poor bonding can be difficult. Any irregularities in the bonding of the sheet of polymer to the silicon substrate causes variations in the performance of the device. Furthermore, the bonding process is not a step familiar to those skilled in the production of silicon integrated devices and it is therefore not a simple matter to convert existing processing facilities for use in producing such devices. It is not repeatable, controllable or suitable for mass production.

According to a first aspect, the invention provides a method of producing a transducer comprising applying a sacrificial material to a substrate, applying a polymer coating over at least part of the sacrificial material and the substrate, and removing at least part of the sacrificial material to leave a portion of the polymer coating defining a movable

member wherein the member defines a part of a cavity, and in which the polymer coating is applied in a mobile state.

Preferably the polymer coating is applied over substantially the whole of the sacrificial material.

Preferably substantially the whole of the sacrificial material is removed.

The movable member may be deflectable and/or deformable. The movable member may comprise a membrane.

The movable member may define a membrane of an ultrasonic or acoustic transducer. Alternatively, it may define a displaceable mass (for example the plate of an accelerometer).

Thus, whereas in prior ultrasonic transducers in which a substantially rigid sheet of material is glued to a substrate to form a membrane, the membrane material of the present invention is highly mobile (e.g. a liquid) in the application state. The member, or membrane, can therefore adhere itself to the substrate without the need for a separate adhesive as the polymer is cured following application.

The method may thus comprise providing a layer of sacrificial material on the substrate, using the sacrificial material to assist in defining the shape of the cavity/movable member, and removing the sacrificial material after the shape of the cavity defined by the polymer member and the substrate has been established.

The method may comprise dissolving away, or otherwise removing, some or all of the sacrificial material within the cavity after the polymer material has been, at least partially, cured. Preferably the sacrificial material is removed after the polymer material has been substantially fully cured.

The method may therefore comprise applying a layer of sacrificial material over a substrate, which is preferably a semiconductor material, such as silicon or galium-arsenide and forming the sacrificial layer to create a profiled terrain. Projections of sacrificial material may be created extending away from the substrate or alternatively recesses may be provided in the substrate which are filled with sacrificial material. Preferably regions of the sacrificial layer are completely removed prior to the application of the polymer material, so that the polymer material contacts the substrate directly in parts, and overlies the sacrificial material in other parts, where it is applied. Islands of sacrificial material may be created.

The sacrificial layer may be shaped using surface micromachining techniques. For example it may be shaped, using photolithographic mask techniques - e.g. optical, x-ray, electron beam techniques in conjunction with etching techniques, (e.g. wet or dry etching), or by other suitable direct removal techniques e.g. laser or focussed ion beam.

Surface micromachining techniques are well known in the production of semiconductor devices. Much of the equipment and techniques used to perform surface micromachining exists and is based on that used for fabricating microelectronics (e.g. CMOS technology). It is preferable to produce the transducer using standard micromachining technologies and as many common materials as possible within existing

commercial semiconductor device production facilities. The process proposed is a low temperature process (approximately 400°C or less) and is compatible with existing electronics technology, e.g. CMOS.

Surface micromachining enables us to produce a polymer membrane ultrasonic transducer in a more controllable way, and with a higher yield than other techniques for producing ultrasonic transducers. Furthermore, the polymer membrane ultrasonic transducers produced are more compatible with CMOS and bipolar mass production of semiconductor devices than are hand-made transducers with sheets of PCB bonded to a substrate. The properties of the polymer member including mass, thickness, size and shape, and stiffness can all be readily controlled. This leads to control of subsequent transducer properties.

The method may comprise the following additional steps once the dimensions of the substrate, cavity, and membrane have been decided. Firstly, a bottom contact pad material may be deposited onto the substrate. Next, a bottom contact pad mask may be used to define an area for defining the bottom contact pad of the transducer and the material surrounding the mask removed using an etching process. The bottom contact pad material may be applied by sputtering, or other particle deposition processes. The bottom pad may form one electrode of a capacitor and may be metal. Alternatively, a bottom contact pad material may be deposited through a mask.

A pre-step of electrically insulating the surface of the semi-conductor surface may be performed, for example using a layer of silicon dioxide for silicon substrates if such a layer is not already present.

Secondly, the method may comprise the further steps of applying a sacrificial layer over the bottom electrode and using a cavity mask to define the area that will be the cavity of the transducer and removing material from the sacrificial layer not covered by the cavity mask.

Thirdly, a polymer membrane may be applied, e.g. spin coated, over both the sacrificial material and optionally the area of substrate immediately surrounding the sacrificial material to form the shape of the membrane. The membrane material may then be cured.

In a fourth step, the method may comprise applying a top contact pad material onto the surface of the membrane and using a top contact pad mask to define the area of the electrode/top contact pad before removing material outside the masked area to leave only material defining the top contact pad. The top contact pad material may be sputtered on, or otherwise deposited, and removed by etching. Alternatively, a top pad may be deposited through a mask.

Finally, the method may comprise using an etch hole mask to define etch holes, and removing material to produce the etch holes to enable sacrificial material to be etched out, via the etch holes. This leaves a substantially empty (apart from the bottom contact) cavity defining the sensor. The etch holes also enable the pressure on either side of the membrane to be equalised. Thus, the etch holes penetrate completely through the membrane.

As a variation to this fabrication, using the identical sacrificial and membrane layers, a transducer could easily be formed in which the cavity comprises a recess in the substrate surface with the membrane on top.

This would realise a transducer which is substantially flat on the substrate surface.

The production process may therefore be a four mask process.

According to a further aspect the invention comprises a method of producing a micromechanical device comprising applying a polymer material over a substrate when the polymer material is in a mobile state, ensuring that the polymer material has the desired shape and thickness, curing the polymer material, and leaving the cured polymer material as part of the finished micromechanical device.

Although polymer materials have been applied to substrates, such as semiconductor substrates, in the production of micromechanical devices in the past it has been as resists which are later removed during further manufacturing steps: they have not been left in place in the completed device. Furthermore, although silicon chips have been encased in polymer materials for protection (in a finished device), the polymer material has not been a structural, or functional, part of the device which enables it to operate. The realisation that polymer material applied in liquid, or mobile form, bond well to substrates such as silicon/semiconductor substrates and can be used as structural members in a finished device is new. The especial applicability of polymer membranes in transducers, because of the need to control the behaviour of movable transducer membranes closely, and the realisation that the present invention allows a higher yield when manufacturing such devices is also part of some aspects of the invention.

Preferably the polymer material forms a movable member.

The movable member may comprise part of an ultrasonic transducer or an accelerometer.

The method may comprise producing an array of transducers on the same substrate, and/or ensuring that there are transducers which respond to different frequencies. The method may further comprise linking the cavities of selected transducers to modify the performance of an array of transducers. This can be achieved by micro-machining channels into the insulating layer between where the subsequent resonant cavities would be formed later in the sequence. This could be done using lithographic masking and etching. An extra sacrificial layer could be introduced on top of these channels which may overlap the edges of the channels and the regions where the cavities would be formed. The extra sacrificial material in the channels could then automatically be removed during the final etching of the material defining the cavities.

The method may comprise providing an integrated semiconductor device having the transducer and having signal processing means provided on the same substrate. The signal processing means may be defined in the semiconductor device in a first stage, and the micromechanical device or transducer created in a subsequent stage. The formation of the transducer does not damage the circuitry of the signal processing means as it is formed using a low temperature process.

The production of the integrated semiconductor device that incorporates a polymer membrane ultrasonic transducer is greatly facilitated by making the transducer using surface micromachining techniques. Both etching and spin coating are well developed techniques in semiconductor fabrication, and so commercial plants can be readily adapted to produce the transducers of the present invention. The spin

coating is a low temperature technique, allowing membranes to be applied to substrates which include pre-defined electronic circuits without damaging the circuits.

By getting the processor close to the sensor we reduce noise and can detect lower signals than would otherwise be possible. Since we may wish to detect very small changes in capacitance in the transducer, being able to have integrated electronics can be significant. Integration of the transducer with the control/processing electronics enables us to provide very small micromechanical devices.

The polymer material may be a polyimide, and is preferably PIQ™ (available from Hitachi). The polymer material may be applied to the substrate, or to sacrificial material if it is provided as a liquid, and is spread out over the surface of the substrate or sacrificial material to coat it. The polymer material may be spun coated onto the substrate and/or sacrificial material, centrifugal forces being used to control the thickness of the coating. A knowledge of the physical properties of the material in its mobile viscous (liquid) state can be used to control the processing conditions, e.g. spin coating.

According to a third aspect the invention provides a transducer having a substrate and a polymer member or structure in which the member has either (a) been applied in a mobile state and then cured; and/or (b) been applied over a sacrificial material which has then been removed.

Preferably the movable member has a profiled, non-flat, shape. Preferably the member is movable. The member may define part of a cavity. The cavity may have an upper wall and side walls defined by the

membrane. The substrate may have a substantially flat surface in the region of the cavity.

The membrane is preferably made of polyimide or another semiconductor polymer material.

The bandwidth of the transducer operating as an ultrasonic transducer, for example in structural application, may be of the order of several kHz to several Mhz, preferably in the range of 100kHz-10 Mhz, or 1-8 Mhz, or 2-6 Mhz, or at least 3, 4 or 5 Mhz. The Q factor may be low compared to devices using other semiconductor membranes. Of course, for other applications the bandwidth could be very different, e.g. from Hz to Mhz.

According to a fourth aspect of the invention an integrated semiconductor device is provided having an ultrasonic transducer in accordance with the second aspect of the invention provided on a semiconductor substrate and a signal processor or signal modifier provided on the same semiconductor substrate, integrating the processor and the transducer in the same device.

According to a fifth aspect, the invention provides an integrated semiconductor device having a plurality of ultrasonic polymer membrane transducers provided as an array.

The array may have associated with it, on the same semiconductor substrate, signal processing or signal conditioning electronics.

According to a sixth aspect, the invention provides a structure comprising a semiconductor substrate having a polymer member defined

thereon, in which the polymer member is applied to the substrate in a mobile state.

The member may be movable or non-movable. The member may be rigid, and may define part of a cavity. It may define a membrane or cover over the cavity, or define a lever or projection extending from the substrate.

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings, in which:-

Figure 1 schematically shows an ultrasonic transducer in accordance with the invention;

Figure 2 shows a plan view of the transducer of Figure 1;

Figure 3 shows schematically a prior art transducer;

Figure 4 schematically shows an integrated array of transducers, with linking of chambers; and

Figure 5 is a cross-section on line VII-VII of Figure 4.

Figure 3 illustrates the prior art arrangement for producing ultrasonic transducers comprising a substantially rigid, planar polymer membrane attached to a silicon substrate. A sheet of the membrane material is taken and attached to a silicon substrate material 12, which has had formed in it a recess 14. The sheet of membrane material is, typically, glued onto the silicon substrate. There can be problems adhering the sheet of material properly to the silicon substrate, for

example areas where poor bonding/no bonding at all has taken place are schematically illustrated in Figure 3 as dark areas 16. These will influence the operational performance of the transducer. Since the imperfections in bonding are not predictable, each transducer that is made will perform slightly differently. It is very difficult to achieve control of this type of response. Furthermore, if there are too many poor areas of bonding, or poor areas of bonding too close to the recess 14 (e.g. at its peripheral edge) then the transducer may not operate properly at all. The prior art production of ultrasonic transducers with polymer membranes has a high failure rate, and a low yield.

Figure 1 schematically illustrates a new transducer produced using the present invention. A silicon substrate 20 has a dielectric coating 22 (and in this example the dielectric is silicon dioxide), and a polymer membrane 24 (in this example a membrane made of PIQ™) extends over the dielectric 22 and defines a cavity 26 between a raised part of the membrane 28 and the dielectric/silicon substrate. Air is typically provided in the cavity 26, but some other contents may be provided for some circumstances.

The polymer membrane defined in the raised region 28 has side wall regions 30 which extend away from the dielectric/silicon substrate, and a top wall region 32 which extends generally parallel to the substrate. A metal bottom contact pad 34 is provided on the dielectric 22 in the cavity 26, and a top contact pad 36 is provided on top of the raised portion 28 of the polymer membrane.

The operating principle of the transducer is the same of that of conventional capacitive type acoustic sensors in that the raised portion 28 of the polymer membrane is deflected by an incident acoustic (pressure)

wave and that deflection results in a change in the capacitance between the top contact pad 36 and the bottom contact pad 34 as the top contact pad 36 moves relative to the bottom contact pad 34. The change in capacitance is measured, and this is used to derive the output of the ultrasonic transducer.

To manufacture the transducer of Figure 1 we use silicon surface micromachining technology.

A silicon substrate is surface cleaned using automated water cleaning equipment and then thermally oxidised in conventional semiconductor furnace equipment. An insulating layer of silicon dioxide is formed, approximately 6000Å (angstroms) in thickness.

The bottom (fixed) electrode is formed on the silicon dioxide by sputter depositing a combination of different metal layers to form a sandwich structure. A thickness of approximately 4000Å (angstroms) of titanium-tungsten (TiW) and aluminium silicon (AlSi) layers are employed. TiW is employed as the principle bottom electrode material. This is because AlSi is employed as the sacrificial layer for the resonant cavity, and this sacrificial layer must later be removed with the bottom electrode remaining intact. An AlSi layer as part of the bottom electrode structure serves to protect the TiW during the polyimide etch which occurs later, and during which any unprotected TiW material would also be etched. The bottom contact pad is defined in the deposited metal layers using an (optical) lithographic process and conventional photoresist mask, followed by a reactive ion etch (RIE), based on a combination of chemistry's; CF_4, O_2 and BCl_3, Cl_2, CHF_3 (for TiW and AlSi respectively).

The sacrificial layer is introduced over the regions of bottom metal contact pad and oxidised silicon surface. Aluminium silicon (AlSi) is sputter deposited to a thickness which would subsequently set the resonant cavity thickness. This thickness is dependent on the required ultrasonic performance of the device but typically may be of the order of a few micrometers (10^{-6} m). The size and shape of the resonant cavity is defined in the sacrificial layer using an (optical) lithographic process and conventional photoresist mask, followed by a reactive ion etch (RIE), based on a BCl_3, Cl_2, CHF_3 chemistry.

The polymer membrane is next formed over the entire substrate, covering the areas of sacrificial material. This is done using automated equipment by dispensing polyimide (Hitachi PIQ™), in liquid form, onto the substrate and spinning the substrate at high speeds to produce a known film thickness, typically 1 to 3μm, which is governed by the ultrasonic properties required for the transducer. The membrane must ideally be a highly uniform film, with specific mechanical properties (intrinsic stress), and with absolute minimal defects. Adequate preparation and cleaning of the substrate surface should be performed prior to this step, and after previous lithographic masking and etching, to ensure good adhesion between the polyimide and substrate materials. The polyimide is then 'cured' with a thermal treatment to harden the film, but also importantly for this transducer application to control its mechanical properties i.e. ideally to set a low intrinsic tensile stress. This is done at approximately 370°C in conventional semiconductor furnace equipment.

The top electrode, which forms the movable plate of the variable capacitor attached to the deflectable membrane, is next introduced. This is done by sputter depositing a metal layer of titanium-tungsten (TiW) on top of the polyimide membrane. This process is critical in that the metal

deposition conditions must be carefully controlled in order to minimise any effect on the mechanical properties of the membrane, which ultimately govern the ultrasonic properties. A substrate pre-bake is employed to minimise 'outgassing' from the polyimide film during deposition. Chamber conditions in the sputtering equipment must be controlled such as pressure, as must the deposition temperature. A typical thickness would be approximately 1000Å to 2000Å of TiW material, deposited at approximately 250°C or higher. The top contact pad is defined in the deposited metal layer using an (optical) lithographic process and conventional photoresist mask, followed by a reactive ion etch (RIE), based on a CH_4, O_2 chemistry.

The next stage is to introduce the etch holes through the top metal electrode and membrane materials down to the top of the sacrificial layer. Etch holes are defined using an (optical) lithographic process and conventional photoresist mask, followed by a combination reactive ion etch (RIE) of the metal and polyimide materials. The etch holes must allow sufficient access for an etchant material to be able to remove the sacrificial layer and form the resonant cavity. However, since the mass and stiffness of the membrane contribute to the ultrasonic properties of the transducer, holes introduced through the membrane should be designed to have a minimum effect. Hence a number of very small etch holes (approximately 3μm diameter) with a reasonable spacing (10's of μm)are employed. The RIE steps utilise a combination of chemistry's; CF_4, O_2 and CHF_3, O_2 (for TiW and PIQ respectively).

The final stage is to use a suitable etchant material to remove the sacrificial layer (AlSi) from under the membrane. The substrate is immersed in a proprietary metal etch solution (ISOFORM) for a time sufficient to permit the etchant to penetrate the etch holes, and laterally

etch the sacrificial AlSi between the etch holes, and completely clear the resonant cavity. Substrates are then rinsed and dried.

It will be appreciated that in comparison with the prior art shown in Figure 3, the membrane 24 is profiled: it extends away from the surface of the silicon substrate (it could also be flat to the surface if the cavity is recessed). Furthermore, the polymer membrane is applied as a liquid, and this improves the bonding - it is different from applying a pre-formed sheet of material to the silicon substrate. The use of the sacrificial material to define the cavity positively (by having contact between the polymer membrane and the sacrificial material whereupon the membrane is setting/curing so as to give support to the membrane) gives better control of the shape and size of the cavity than the prior art (in which the sheet of polymer may sag into the recess 14 depending upon the conditions experienced).

The surface micromachining techniques used to produce the transducer of Figure 1 could also be used to link resonant cavities of transducers in an array.

Figures 4 and 5 show an arrangement where two adjacent chambers 70,72 have been linked by a passage 74. In Figure 5, passage 74 is shown as being a central passage forming a symmetrical "double" chamber, but the arrangement could be non-symmetrical (for example the lower two chambers of the device of Figure 5 could be linked by a passageway that is non-symmetrically disposed relative to the centre-lines of the two chambers).

It will be appreciated that the polymer material used to make the movable member of the transducer needs to have certain mechanical and

chemical properties, but it is unlikely that PIQ™ will be the only material suitable. The membrane needs to be able to bond well to the substrate/silicon dioxide dielectric. It needs to be able to have the metal top contact pad sputter-deposited on it, and needs to be able to withstand the conditions experienced during that sputtering operation (e.g. it needs to be able to withstand temperatures of a few hundred degrees centigrade). The polymer material should not have too high an intrinsic stress or when the sacrificial material is removed it will deform to a shape that is not carefully defined, and thereby make the production of ultrasonic transducers less predictable. The polymer material needs to be self-supporting when cured, again so as to control its shape. The polymer material needs to be able to withstand attack by the etching substances used in the removal of the sacrificial material. The polymer material needs to be an electronically compatible material - having little or no impurities likely to influence the electronic operation of the device. We believe that polyimide materials are best suited to forming the membrane, although we do not wish to be restricted to these. The materials traditionally used for photo-resist during CMOS manufacturing techniques may be suitable as membranes, and the techniques, and equipment developed for applying photo-resist may be readily adapted to application of the membrane material.

It will be appreciated that in order to make arrays of transducer elements with their resonant cavities interconnected with sub-channels, this can be done using an additional metal-based sacrificial layer. For example, we could make discrete sacrificial layer-material raised portions, such as would be used to form the array shown in Figure 4, and then create "bridges" of further sacrificial material between the original arrays, at the locations wanted, by applying another layer of sacrificial material and then removing it in areas that are not for bridges.

It is envisaged that the transducers will have applications in structural monitoring, medical imaging, guidance and positioning apparatus. Protection is sought for such apparatus incorporating a transducer in accordance with the invention. Actuators and displacement sensors are also envisaged.

Although ultrasonic transducers have been discussed, there may be occasions when the invention is applicable to acoustic transducers, and again protection in this area is sought.

Since various transduction mechanisms govern the subsequent device performance (for example the Q) in ultrasonic devices, surface micromachining permits control over these different mechanisms by controlling the device structure parameters (for example the membrane mass, the stiffness, the size of cavity, and the ability to link cavities together in an array).

Of course, it will be readily understood that in one aspect the present invention lies in the production of a transducer of the kind in which the membrane is applied in a mobile state whilst supported by a sacrificial material, the membrane then being cured and the sacrificial material being removed. A micromachined polymer membrane is seen as being new and advantageous. The cavity defined by the membrane and the substrate may protrude above the surface of the substrate (as shown in the accompanying drawings). Alternatively, a hole or recess could be formed in the substrate which is filled (wholly or partially) with sacrificial material to support the membrane during manufacture. The word cavity is not intended to be restricted to meaning a be fully enclosed

area covered by the membrane, but includes a partially closed cavity, or a cavity defined by a membrane "bridge" over a void.

Also, the skilled man would readily understand that the material need not be in a fully liquid state when applied, but could be in any form whereby it will be deformed under its own weight or under gravity (due to, for example, spin coating) to take up a desired form before being cured (by temperature or any other process) to take on a permanent form.

The polymer member or structure applied in mobile form need not necessarily be movable. For example it could protect a structure beneath it, or could form a window for the passage of a variety of measurands. The polymer member or structure could be a mechanical structure defining part or all of a desired formation (for example it could comprise a cover, which may define in part one or more chambers or channels).

CLAIMS

1. A method of producing a transducer comprising applying a sacrificial material to a substrate, applying a polymer coating over at least part of the sacrificial material and the substrate, and removing at least part of the sacrificial material to leave a portion of the polymer coating defining a movable member wherein the member defines a part of a cavity, and in which the polymer is applied in a mobile state.

2. A method according to Claim 1 in which the polymer coating is applied over substantially the whole of the sacrificial material.

3. A method according to Claim 1 or Claim 2 in which substantially the whole of the sacrificial material is removed.

4. A method according to any preceding claim which comprises a low temperature process.

5. A method according to any preceding claim in which the movable member defines a membrane of an ultrasonic or acoustic transducer.

6. A method according to any one of Claims 1 to 4 in which the movable member comprises a deflectable mass of an accelerometer.

7. A method according to any preceding claim in which as the polymer is applied in a mobile state, the sacrificial material assists in defining the shape of the polymer membrane, and which further comprises removing the sacrificial material after the shape of the polymer member has been established.

8. A method according to any preceding claim in which the sacrificial material is applied over a substrate to create a profiled terrain.

9. A method according to any preceding claim in which a layer of sacrificial material is applied and in which regions of the sacrificial layer are removed prior to the application of the polymer.

10. A method according to any preceding claim in which the substrate is a semiconductor material.

11. A method according to any preceding claim which comprises using a cavity mask to define an area that will be the cavity of the transducer and removing material from the sacrificial material not covered by the cavity mask.

12. A method according to Claim 11 which further comprises applying a top contact pad material onto the membrane, and etching the material through a mask to define a top contact pad.

13. A method according to Claim 11 or Claim 12 which further comprises the step of forming etch holes through the membrane, and removing material to produce the etch holes to enable sacrificial material to be etched out of the cavity, via the etch holes.

14. A method according to any preceding claim which comprises producing an array of transducers on the same substrate.

15. A method according to Claim 14 which further comprises ensuring that there are transducers which respond to different frequencies.

16. A method according to Claim 14 or Claim 15 further comprising linking the cavities of selected transducers to modify the performance of an array of transducers.

17. A method according to any preceding claim which further comprises providing an integrated semiconductor device having the transducer and having signal processing means provided on the same substrate.

18. A method according to any preceding claim in which the polymer material used is a polyimide.

19. A method according to any preceding claim in which the polymer material is spun coated onto the substrate and/or sacrificial material with centrifugal forces being used to control the thickness of the coating.

20. A method of producing a transducer substantially as described herein with reference to the accompanying drawings.

21. A transducer having a substrate and a polymer member or structure in which the member has either (a) been applied in a mobile state and then cured; and/or (b) been applied over sacrificial material which has then been removed.

22. A transducer according to Claim 21 in which the member defines at least part of a cavity.

23. A transducer according to Claim 21 or Claim 22 in which the member has a profiled, non-flat, shape.

24. A transducer according to any one of Claims 21 to 23 in which the member is made of a polymer such as polyimide.

25. A transducer substantially as described herein with reference to the accompanying drawings.

26. An integrated semiconductor device having a transducer in accordance with any one of claims 21 to 25 provided on a semiconductor substrate and a signal processor or signal modifier provided on the same semiconductor substrate, integrating the processor and the transducer in the same device.

27. An integrated semiconductor device having a plurality of polymer member transducers provided as an array.

28. An integrated semiconductor device according to Claim 27 in which the array has associated with it, on the same semiconductor substrate, signal processing or signal conditioning electronics.

29. A method of producing a micromachined device comprising applying a polymer material over a substrate when the polymer material is in a mobile state, ensuring that the polymer material has the desired shape and thickness; and curing the polymer material so as to form a member or film of polymer material.

30. A method according to Claim 19 in which a sacrificial material is provided on the substrate over which the polymer material is applied, the sacrificial material assisting in defining the shape of the polymer member and supporting the member at least until the polymer material is cured.

31. A method of producing a micromechanical device comprising applying a polymer material over a substrate when the polymer material is in a mobile state, ensuring that the polymer material has the desired shape and thickness, curing the polymer material, and leaving the cured polymer material as part of the finished micromechanical device.

32. A method according to claim 31, in which the polymer material forms a movable member.

ABSTRACT

IMPROVEMENTS IN AND RELATING TO MICROMECHANICAL DEVICES

A transducer and method of making the same is disclosed comprising applying a sacrificial material to a substrate (20), applying a polymer coating (24) over at least part of the sacrificial layer and the substrate (20), and removing at least part of the sacrificial material to leave a portion of the polymer coating defining a movable member to define a cavity, the polymer coating being applied in the mobile state. The sacrificial material may be removed by providing etch holes in the polymer coating and removing material through the holes.

To be accompanied, when published, by Figure 1 of the accompanying drawings.

FIG. 1

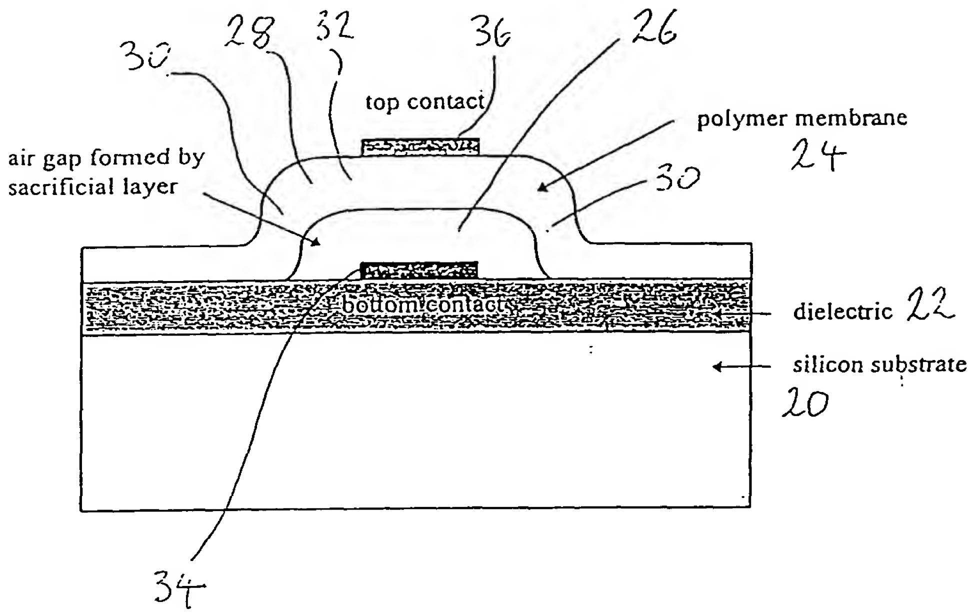
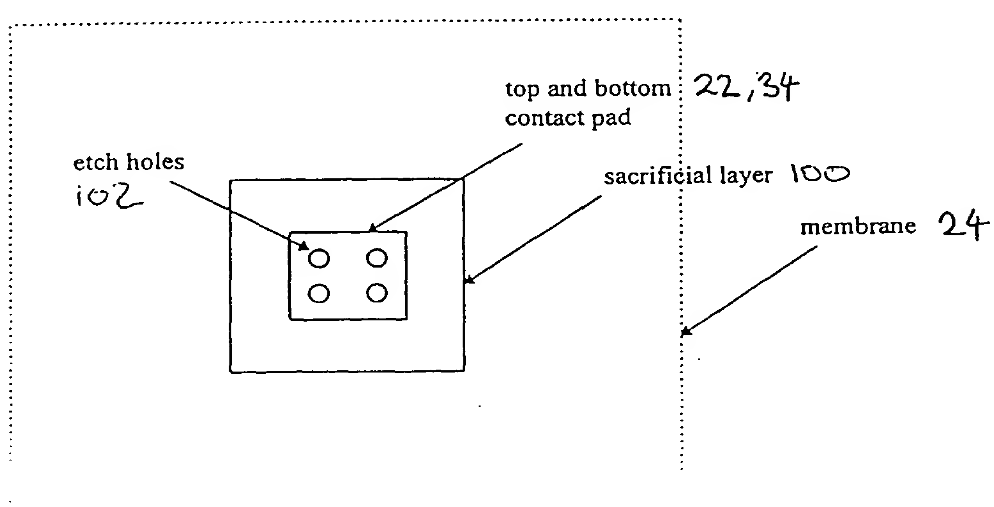


FIG. 2

Plan View



NOT TO BE AMENDED

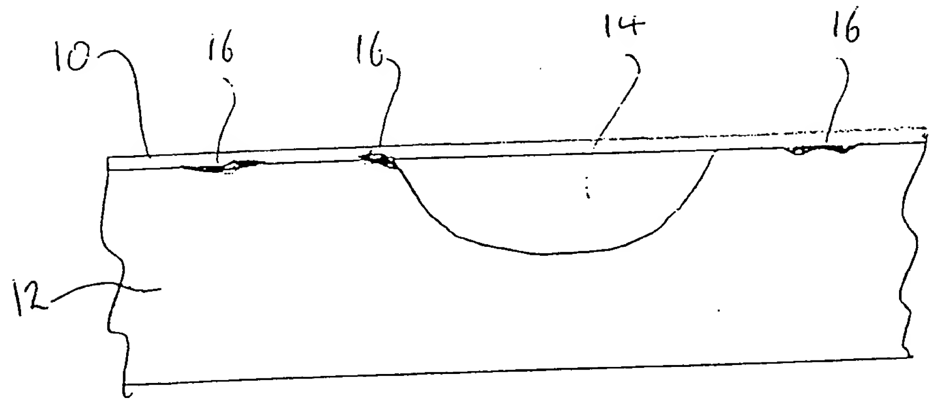


FIG 3 PRIOR ART

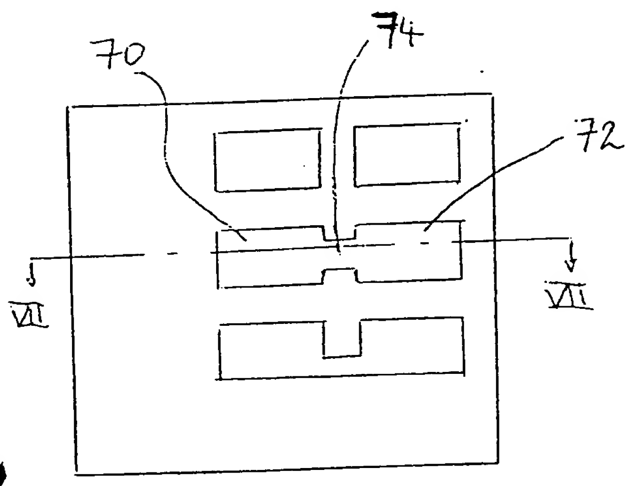


FIG 4

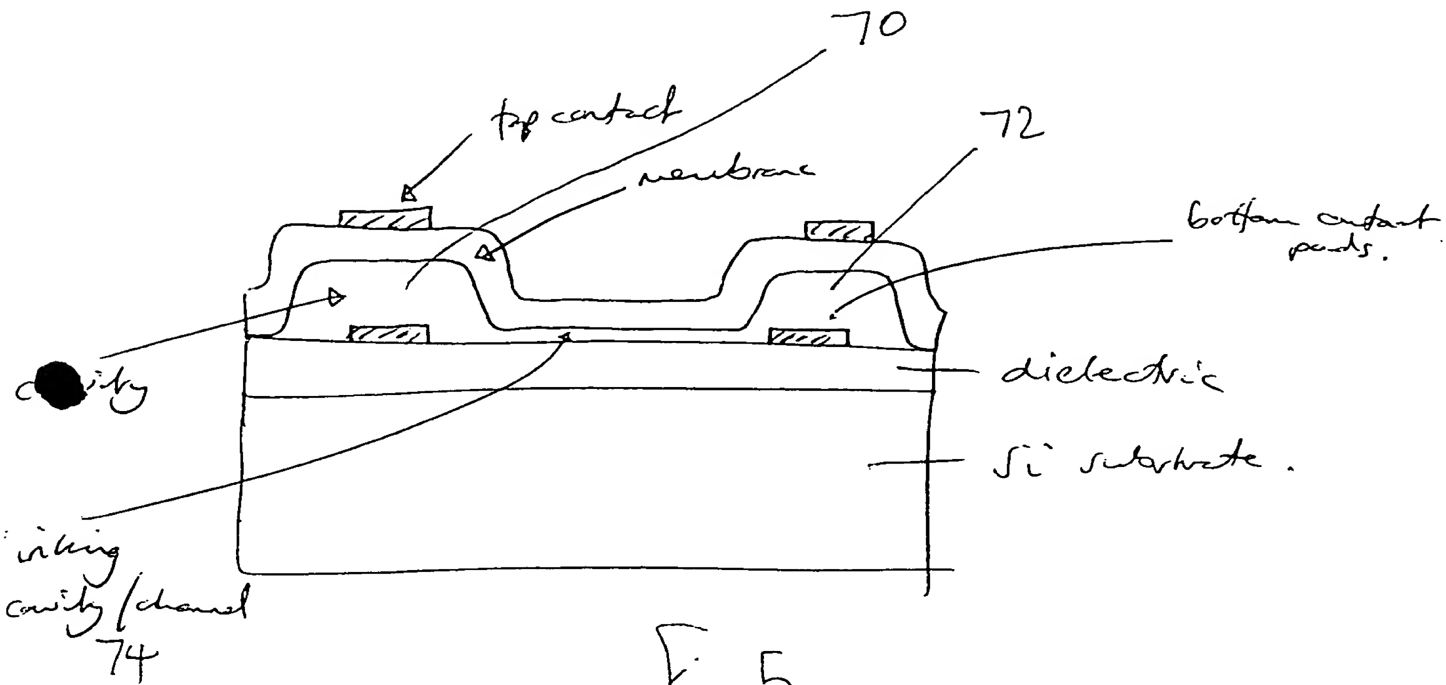

70
top contact
72
membrane
bottom contact pads.
cavity
dielectric
Si substrate.
wicking cavity/channel
74

Fig 5